Ocean Response Coastal Analysis System

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LONG-TERM GOALS

The joint goal of the Naval Research Laboratory (NRL) and the Commander, Meteorology and Oceanography Command (CNMOC) is to develop a capability to describe diver visibility and vulnerability, and demonstrate how new technology allows a better 3D/4D representation of the optical field for Navy applications.

OBJECTIVES

The objective of this joint NRL and CNMOC effort is to test new diver visibility and vulnerability algorithms and develop standard Navy products that are acceptable to the warfighter. This involves testing and validating new optical instrumentation for Fleet applications and as input into the NAVOCEANO's LOGIC framework and database.

APPROACH

In support of diver operations in any area of interest, the Navy (via the Naval Oceanographic Office (NAVOCEANO)) provides optical planning products to support the mission. At present, these products focus around an estimate of diver visibility in the horizontal (addressing the issue of how far they will be able to see) and an estimate of vertical visibility (addressing the issue of how easily they will be seen). These products depict either a monthly or seasonal average; however, they are inadequate to support most littoral operations and do not forecast for areas where the optical properties can change over finer scales than modeling and remote imagery reveal. Given recent developments in optical instrumentation and the application of collected data to Navy issues, the technology now exists to provide better estimates of diver visibility and vulnerability. To identify and mitigate gaps in R&D and the transition process, CNMOC established the project Gauging Littoral Optics for the Warfighter (GLOW).

GLOW was initiated in 1998 and to date has conducted two experiments in which existing algorithms for diver visibility were applied to field data and then compared to actual visibility as observed by Navy divers. Until recently, optical measurements used to support diver visibility and

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vulnerability have relied on Secchi depth values taken from surveys as far back as the 1930's. These data simply cannot represent the dynamics seen in any coastal environment. In addition, the derivation of visibility (horizontal and vertical) from Secchi depth is very subjective. With the advent of relatively new instruments such as the WET Labs absorption-attenuation meters, improved measurements of optical properties are available. Such data are currently being used to populate the optical databases of NAVOCEANO and thus are vital source material for Fleet support products. However, the algorithms deriving visibility from optical properties were formulated prior to the development of these modern *in situ* instruments as well as modern air and space-based radiometers. These algorithms must be tested in light of these improved measurements to determine if the models of the past are applicable and to determine the best optimized products given our improved measurement potential. Toward this end, CNMOC and NRL funded a preliminary study deploying divers and optical sensors at the same time and in the same place. The results indicated that, indeed, visibility algorithms need to be reviewed and most likely revised (actual diver visibility was underestimated by theory by a factor of 2 to 3). With these experiments, GLOW has identified the R&D need to revalidate/revise existing diver visibility algorithms and to standardize the elements of both daytime and nighttime vulnerability. In response to the uncertainty in diver visibility, McBride (unpublished) developed a model that included turbid water backscattering, contrast differences, ambient light, and viewing angle. This model has been incorporated into NAVOCEANO's Littoral Optics Geospatial Integrated Capability (LOGIC).

LOGIC is the GIS-based system used by NAVOCEANO to integrate and analyze optical data, to generate optical support products such as diver visibility and vulnerability for Fleet applications, and to facilitate transitions from R&D. The LOGIC framework already provides estimates of diver visibility using the Preisendorfer algorithms (Duntley, 1952; Preisendorfer 1976, 1986) tested under GLOW 1 and GLOW 2. The advancements in this proposal are several fold. The development of the Ocean Response Coastal Analysis System with its small autonomous profiling instrumentation will allow a more accurate 3D/4D representation of the optical field. The maxi-profiler together with four mini-profilers will be used to provide real-time estimates of the optical field. However, algorithms that use the output of these instruments must be compared against a more complete optical set of measurements as well as actual diver visibility and vulnerability measurements. Thus, this program will apply the developed profiling technology to specific military applications by collaborating with the GLOW project. The participation by the Navy in this program is targeted toward several areas: 1) testing and improving or developing algorithms to relate optical measurements to warfighter concerns of diver visibility and vulnerability, 2) utilizing small, autonomous sensor suites to provide optical properties for Navy applications, 3) utilizing maxi-sensor packages with state-of-the-art scattering and absorption instrumentation as source data for Navy algorithms, databases, and products, and 4) validating new optical instrument technology to implement into LOGIC and to develop enhanced, Navy-relevant products.

The development of the ORCAS with its small biological, nutrient, and optical sensors is to be tested in Narragansett Bay at the end of year two, with a full deployment in the Gulf of Mexico in year three of this program. To be prepared for deployment of this sensor suite, CNMOC and NRL will integrate a bioluminescence sensor into the maxi-sensor to allow diver vulnerability to be quantified and then conduct a series of diver visibility and vulnerability exercises with Navy and NOPP assets. These exercises will be designed to test revised new visibility algorithms available to the Fleet (McBride, Maffione) and to test the availability of input parameters for these models.

The exercises in years one and two will be conducted at the Longterm Ecological Observation station in 15 meters of water (LEO-15) in collaboration with the Coastal Ocean Observation

Laboratory (COOL). This site has been selected for studies since contrast targets, an imaging camera, and several profiling optical packages will be deployed by other projects. The first LEO-15 exercise will take place in July 2000 and will use prototype instrumentation that will be integrated into the ORCAS optical packages. Navy divers will be used to compare observed visibility and new algorithms (applied to *in situ* data) tested against several targets. The data will be compared to that collected in GLOW 1 & 2, and a recommendation of which algorithm to use in Navy applications will be made.

Year one and two will also involve the development of a standard vulnerability model for use by the Fleet. Presently, the only nighttime diver vulnerability model is a qualitative scale developed by LaPota and Geiger (unpublished). However, the new bioluminescence sensor should provide the Navy and scientific community with enhanced spatial and temporal information on bioluminescence potential. The first two years will be used to add bioluminescence to the visibility models and to refine diver vulnerability estimates using available optical and biological data collected by ORCAS. At each exercise, visual vulnerability will be validated through the collaboration of Navy divers and other warfare specialists. In addition, military-supplied equipment to enhance nighttime detection will be used, when available, to further test low-light vulnerability. The results will be incorporated into the diver vulnerability algorithms.

For both visibility and vulnerability experiments, any available remote ocean color imagery will also be included in the analyses. Although *in situ* measurements and resultant capabilities are the focus of this work, remote imagery is an important complement for characterizing the synoptic field and for potentially gathering preliminary data in “denied access” regions prior to the covert deployment of an operational ORCAS system in the future.

The last task is in optimizing products for Fleet applicability and making the products “user-friendly” by putting the users in the loop and getting their feedback on the product. This provides a product that is realistic to the operational community and thus is more likely to be used by them. As products become developed under the LOGIC framework, candidate products for diver visibility and vulnerability will be presented to the Fleet for their consideration. If they like the product, this program will recommend advancement of the product as a candidate for a standard product (e.g., the Oceanographic and Atmospheric Measurement Library) and suggest that it go through the validation and verification process within the Fleet.

WORK COMPLETED

This project has just been initiated. NRL is in the process of selecting a bioluminescence sensor for this study. Dr. Jim Case from University of California, Santa Barbara has submitted a proposal to NRL for a Cooperative Grant that would allow expertise in the bioluminescence field to be on the NOPP team. The BER-LUX bioluminescence sensor would then be selected for use in the upcoming LEO-15 exercise. NRL and CNMOC have both selected several potential visibility algorithms that need to be tested throughout the year.

RESULTS

Since this program is just starting there are no results for this program at this time.

IMPACT/APPLICATIONS

The impact of GLOW 1 and 2 has already resulted in the Navy taking a critical look at the products and the input parameters for use in diver visibility and vulnerability support to the Fleet. The GLOW 1 exercises resulted in Dr. McBride's formulation of a diver visibility model based on optical properties being collected by the Fleet.

TRANSITIONS

No transitions have occurred at this early stage of the program.

RELATED PROJECTS

LCDR Davis-Lunde has a separate project within NAVOCEANO that builds the LOGIC framework for input and analysis of mission critical METOC optical parameters for dissemination to the Fleet.

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